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Datasheet for the decision of 22 July 2022

Case Number: T 0348/21 - 3.4.02

Application Number: 17001442.7

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Language of the proceedings: EN

Title of invention:
SELF-CALIBRATION OF AN INTERTIAL SYSTEM

Applicant:
Northrop Grumman Systems Corporation

Relevant legal provisions:
EPC Art. 83, 111(1)

Keyword:
Sufficiency of disclosure (yes)
Remittal for further prosecution (yes)

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Case Number: T 0348/21 - 3.4.02

D E C I S I O N
of Technical Board of Appeal 3.4.02
of 22 July 2022

Appellant: (Applicant)	Northrop Grumman Systems Corporation 2980 Fairview Park Drive Falls Church, VA 22042-4511 (US)
Representative:	Schmidt, Steffen J. Wuesthoff & Wuesthoff Patentanwälte PartG mbB Schweigerstraße 2 81541 München (DE)
Decision under appeal:	**Decision of the Examining Division of the European Patent Office posted on 30 November 2020 refusing European patent application No. 17001442.7 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman	R. Bekkering
Members:	F. J. Narganes-Quijano
	B. Müller

Summary of Facts and Submissions

I. The applicant lodged an appeal against the decision of the examining division refusing European patent application No. 17001442.7.

In its decision the examining division held that the invention defined in the claims of the main and the first auxiliary requests then on file was not sufficiently disclosed within the meaning of Article 83 EPC, and decided not to admit the second auxiliary request to the proceedings.

II. With the statement setting out the grounds of appeal the appellant submitted claims according to a main request and auxiliary requests I and II and filed the following documents:

A1: Extract from *en.wikipedia.org*, entry "Spectral density" (printed on 8 March 2021)
A2: "Spectral Analysis of Signals", P. Stoica *et al.*; Prentice Hall (US), 2005; chapter 1, pages 1 to 21
A3: "Mathematical Handbook for Scientists and Engineers", G. A. Korn *et al.*; McGraw Hill, 1967; chapter 18, lines 585 to 663.

The appellant requested that the decision under appeal be set aside and the application be remitted to the first instance under Article 111(1) EPC.

III. Claim 1 of the main request reads as follows:

"An inertial system (10) comprising:

a gyroscope system (12) comprising a plurality of gyroscopes (14),

the gyroscope system (12) to provide rotation rate data associated with a rotation of each of the plurality of gyroscopes (14) about a sensitive axis of each of the plurality of gyroscopes (14); and

a rotation sensor system (16) that comprises a signal processor (18), the rotation sensor system (16) to calculate navigation data based on the rotation rate data,

the rotation sensor system (16) comprising a self-calibration component(122) that comprises a scale-factor injection controller (124) to designate a first gyroscope (104) of the plurality of gyroscopes (14) for self-calibration during operation of the inertial system (10) and to inject a calibration input signal comprising a predetermined signal profile having a predetermined frequency from the scale-factor injection controller (124) into the first gyroscope (104),

wherein the signal processor (18) generates a scale-factor estimate for the first gyroscope (104) based on a ratio of an output signal of the rotation rate data associated with the first gyroscope (104) to the calibration input signal provided to the first gyroscope (104),

wherein the self-calibration component (122) further comprises a spectral motion analyzer (126) comprising a demodulator (30) to amplitude demodulate the rotation rate data associated with the plurality of gyroscopes (14) based on the predetermined frequency and to analyze a power spectral density (PSD) associated with the demodulated rotation rate data associated with the plurality of gyroscopes (14) to determine if dynamic motion of the gyroscope system (12) affects the rotation rate data of the first gyroscope (104) at the predetermined frequency, wherein

the dynamic motion of the gyroscope system (12) is determined by the rotation rate data associated with a remaining at least one of the plurality of the gyroscopes (106) that is not designated for self-calibration, and

wherein the self-calibration component (122) further comprises a scale-factor validation controller (128) to calculate a figure of merit (FOM) that defines a quantifiable contamination of the scale-factor estimate based on the spectral motion analyzer (126) analyzing the power spectral density (PSD) to determine if the dynamic motion of the gyroscope system (12) affects the rotation rate data of the first gyroscope (104) at the predetermined frequency."

Independent claim 7 of the main request reads as follows:

"A method for calibrating an inertial system (10) comprising a plurality of gyroscopes (14), wherein

the inertial system (10) comprises a gyroscope system (12) and a signal processor (108), the gyroscope system (12) comprising the plurality of gyroscopes (14);

characterized in that the method comprises:

selecting a first gyroscope (104) of the plurality of gyroscopes to implement a calibration procedure;

injecting a calibration input signal comprising a predetermined signal profile having a predetermined frequency into the first gyroscope (104) after selecting the first gyroscope (104);

receiving rotation rate data associated with each of the plurality of gyroscopes (14) corresponding to real-time rotation about an axis of each of the plurality of gyroscopes (14) after injecting the

calibration input signal into the first gyroscope (104);

after receiving the rotation rate data, generating a scale-factor estimate for the first gyroscope (104) by the signal processor (108) based on a ratio of an output signal of the rotation rate data associated with the first gyroscope (104) to the calibration input signal provided to the first gyroscope (104) and amplitude demodulating the received rotation rate data associated with each of the plurality of gyroscopes (14) based on the predetermined frequency of the calibration input signal;

after amplitude demodulating the received rotation rate data, analyzing a power spectral density (PSD) associated with the demodulated rotation rate data associated with the plurality of gyroscopes (14) to determine if dynamic motion of the gyroscope system (12) affects the rotation rate data of the first gyroscope (104) at the predetermined frequency, wherein the dynamic motion of the gyroscope system (12) is determined by the rotation rate data associated with a remaining at least one of the plurality of the gyroscopes (106) that is not designated for self-calibration;

after analyzing the power spectral density (PSD), calculating a figure of merit (FOM) that defines a quantifiable contamination of the scale-factor estimate based on the analyzing the power spectral density (PSD) to determine if the dynamic motion of the gyroscope system (12) affects the rotation rate data of the first gyroscope (104) at the predetermined frequency; and

updating a scale-factor associated with the first gyroscope (104) with the scale-factor estimate based on the demodulated rotation rate data."

The claims of the main request also includes dependent claims 2 to 6 and 8 to 10 referring back to independent claims 1 and 7, respectively.

Reasons for the Decision

1. The appeal is admissible.

2. *Main request - Sufficiency of disclosure (Article 83 EPC)*

The claims of the main request correspond to the claims of the main request underlying the decision under appeal.

2.1 Claim 1 is directed to an inertial system comprising a plurality of gyroscopes and self-calibration means for designating a first gyroscope for calibration during operation of the inertial system, injecting a calibration input signal into the first gyroscope, and calibrating the scale-factor of the first gyroscope on the basis of the rotation rate data of the first gyroscope and the dynamic motion of the gyroscope system. According to claim 1 the calibration involves the analysis of "a power spectral density (PSD) associated with the demodulated rotation rate data associated with the plurality of gyroscopes (14)" to determine if the dynamic motion of the gyroscope system affects the rotation rate data of the first gyroscope.

In its decision the examining division essentially held in respect of the feature of claim 1 of the main request reading "to analyze a power spectral density (PSD) associated with the demodulated rotation rate

data associated with the plurality of gyroscopes (14)" that

- the mentioned rotation rate data seemed to correspond to a plurality of signals,

- the skilled person was able to calculate a PSD of a single signal, but would not understand how to obtain the PSD associated with a plurality of signals, and in particular associated with the rotation rate data of a plurality of gyroscopes, because it was not comprehensible what a PSD of a plurality of signals was, and

- the description mentioned that the PSD corresponded to "the demodulated rotation rate data of the first gyroscope and the gyroscope(s)" (paragraph [0027] of the application as originally filed) and did not disclose how the PSD was calculated.

The examining division concluded that the application did not disclose how the at least two signals of the demodulated rotation rate data of the at least two gyroscopes (i.e. the first gyroscope and the at least one remaining gyroscope) were combined to form a single signal for the determination of the PSD, and that for this reason the skilled person would not be able to carry out the invention (Article 83 EPC).

2.1.1 The board first notes that the skilled person working in the specific technical field under consideration, i.e. the technical field of gyroscope-based inertial systems, is an electronics engineer familiar with the mathematical methods used in this technical field, and in particular with the mathematical tools used in the processing of signals involved in gyroscope-based inertial systems. Furthermore, the power spectral density (PSD) of a signal is a concept pertaining to the processing of signals and belongs to the common general knowledge of the skilled person under

consideration. Therefore, although the application does not disclose any specific mathematical expression relating to the determination of the PSD of a signal, the skilled person knows how to determine the PSD since the corresponding mathematical formula is defined in standard manuals and textbooks on electrical engineering for different types of time-variable signals (see, for instance, document A1, section "Power spectral density", together with section "Applications", sub-section "Electrical engineering"; and document A2, section 1.3; see also document A3, sections 18.10-2 to 18.10-6) as a frequency-dependent power function derived from the time-variable signal by Fourier transform (see document A1, equations 2 and 3 and the last of the equations in section "Power spectral density", and document A2, equations 1.3.7 and 1.3.10; see also document A3, section 18.10-5, together with the first of the equations 18.10-9 and the first of the equations 18.10-4).

It follows from these considerations that the relevant skilled person knows how to determine the PSD of a signal and that the PSD is - as maintained by the examining division in its decision - only defined for a single signal.

2.1.2 The examining division's objection of insufficiency of disclosure (*cf.* point 2.1 above) is based on an interpretation of the claimed feature "a power spectral density (PSD) associated with the demodulated rotation rate data associated with the plurality of gyroscopes (14)" as relating to the determination of one single power spectral density associated with the corresponding data of the whole plurality of gyroscopes, i.e. to the determination of one single PSD of a plurality of signals.

As pointed out by the examining division, "the demodulated rotation rate data associated with the plurality of gyroscopes" referred to in the claimed feature under consideration is not constituted by single data encompassing information on the whole set of gyroscopes, but by multi-component data comprising distinct data for each of the gyroscopes as it can be inferred from the features "provide rotation rate data associated with a rotation of each of the plurality of gyroscopes (14) about a sensitive axis of each of the plurality of gyroscopes", "output signal of the rotation rate data associated with the first gyroscope", "rotation rate data of the first gyroscope", and "rotation rate data associated with a remaining at least one of the plurality of the gyroscopes" of claim 1.

In this context, the claimed feature under consideration can linguistically be interpreted as done by the examining division, i.e. as referring to the determination of one single power spectral density associated with the corresponding data of the whole plurality of gyroscopes, and therefore to the determination of one single PSD of a plurality of signals, but the feature can also linguistically be interpreted - as mentioned by the examining division in its decision (see "Other possible interpretations could be the determination of a plurality of PSDs from the plurality of signal [...]" in point 10.1 of the reasons of the decision) - as referring to the determination of the power spectral density associated with the demodulated rotation rate data associated with each of the plurality of gyroscopes, and therefore to the determination of the PSD for each of the gyroscopes,

i.e. to the determination of a plurality of power spectral densities.

In addition, the skilled person being aware that the PSD is defined for a signal and that there is no technically meaningful concept of a single power spectral density for a plurality of signals (see point 2.1.1 above) would, when reading claim 1 in a normal and technically sensible way, interpret claim 1 as relating to the determination of the PSD for each of the gyroscopes and would disregard as technically meaningless a possible purely linguistic interpretation of claim 1 as requiring the determination of one single power spectral density for all the gyroscopes.

It is also noted that the issue of sufficiency of disclosure of the claimed invention is to be assessed under Article 83 EPC on the basis of the whole application, and that the skilled person, when implementing the claimed invention taking into account the disclosure of the invention in the description of the application as originally filed, would also understand, in conformity with the normal technical reading of the claimed feature under consideration referred to above, that the PSD mentioned in claim 1 refers to a power spectral density for each of the gyroscopes. In this respect, the board relies on the following pages of the description of the application as originally filed:

- paragraph [0027] according to which "the PSD can correspond to an amplitude demodulated time-history of the rotation rate data RATE of the first gyroscope 104 and the gyroscope(s) 106 projected onto the sensitive axis of the first gyroscope 104", this passage implying that the signal RATE (Fig. 3) is a multi-component signal constituted by the rotation rate data of each

gyroscope (see also paragraph [0024] which refers to "a signal RATE, corresponding to the rotation of the gyroscope system 102 about the respective sensitive axes", and paragraph [0028] which refers to "the rotation rate data RATE of the first gyroscope") and that each component is projected as explained in the paragraph for the purpose of determining the corresponding PSD; and

- paragraph [0038] of the description according to which the self-calibration component analyzes "a power spectral density (PSD)" and calibrates the first gyroscope "based on the predetermined frequency of the calibration input signal associated with the rotation rate data of the first gyroscope in the PSD relative to the rotation rate data associated with a remaining at least one of the plurality of gyroscopes in the PSD", this passage, and in particular the expression "gyroscope[s] in the PSD", implying that each of the gyroscopes - in particular, the contribution of each of the gyroscopes to the PSD - is identifiable "in the PSD" and that the so-called "a power spectral density (PSD)" is a multi-component PSD constituted by the power spectral density values associated with the plurality of gyroscopes.

2.1.3 The board concludes that the power spectral density referred to in claim 1 - contrary to the examining division's view - does not consist of one single density value, but of the respective values of the density associated with the demodulated rotation rate data associated with each of the plurality of gyroscopes and that, therefore, the objection of insufficiency of disclosure raised by the examining division in respect of the corresponding claimed feature is not persuasive.

2.2 According to claim 1 the determination of whether the dynamic motion of the gyroscope system affects the rotation rate data of the first gyroscope involves "the calculation of a figure of merit (FOM) that defines a quantifiable contamination of the scale-factor estimate" on the basis of the analysis of the PSD.

In the decision under appeal the examining division held in respect of these features that the description was silent as to how the analysis of the PSD was performed and how the claimed figure of merit was determined from the analysis of the PSD, and in particular silent as to how a contamination was identified from the analysis of the PSD (Article 83 EPC).

2.2.1 The board notes that claim 1 requires the calculation of a figure of merit (FOM) "that defines a quantifiable contamination of the scale-factor estimate on the spectral motion analyzer (126) analyzing the power spectral density (PSD) to determine if the dynamic motion of the gyroscope system (12) affects the rotation rate data of the first gyroscope (104) at the predetermined frequency", and that - as already concluded in point 2.1 above - the relevant skilled person knows how to calculate the claimed PSD.

In addition, according to the description of the application as originally filed

- the analysis of the PSD allows for a determination of whether "dynamic motion of the gyroscope system 120, as determined by the rotation rate data RATE associated with the gyroscope(s) 106, affects the rotation rate data RATE of the first gyroscope 104 [i.e. of the gyroscope designated for

self-calibration] at the frequency associated with the calibration input signal" (paragraph [0027]), and

- the generation of the FOM is "based on the analysis of the PSD, with the FOM corresponding to a metric that can quantify contamination of the scale-factor estimate from dynamic motion, as defined by the rotation rate data of the remaining at least one gyroscope", the FOM then being compared with a predetermined threshold to determine whether the scale-factor estimate is acceptable (paragraph [0012]; see also paragraphs [0020] and [0028]).

In the board's opinion the relevant skilled person (*cf.* point 2.1.1 above) would understand from these passages that

- an analysis of the PSD - in particular, a comparison of the PSD values corresponding to the projection of the amplitude demodulated time-history of the rotation rate data of the gyroscopes onto the sensitive axis of the first gyroscope at the claimed predetermined frequency, i.e. at the frequency of the calibration input and therefore at the demodulation frequency (description, paragraphs [0027] and [0047]) - would allow the determination of whether the dynamic motion of the gyroscope system affects the rotation rate data of the first gyroscope and, therefore, of whether the scale-factor estimate is contaminated by the dynamic motion, and that

- the mentioned analysis - in particular, the mentioned comparison of values - would allow for a quantification of the degree of contamination of the scale-factor estimate by the dynamic motion of the gyroscope system.

In this context the skilled person, on the basis of the common general knowledge in this technical field, would consider several possible options for defining in terms

of the mentioned quantification of the degree of contamination a FOM fulfilling all the claimed requirements. In particular, the FOM can, as submitted by the appellant, be based on the values of the PSD itself - in particular, on a quantification of the difference of the values of the PSD corresponding to the projected demodulated rate data referred to above.

2.2.2 In view of these considerations the board concludes that, although the description of the patent does not describe any specific example of a FOM, the relevant skilled person is in a position to determine a FOM fulfilling all the claimed requirements on the basis of the description of the patent and the common general knowledge in this field.

2.3 Independent claim 7 is directed to a method for calibrating an inertial system, the steps of the method being essentially in one-to-one correspondence with the functional features of the different components of the inertial system defined in claim 1. Therefore, the objections raised by the examining division under Article 83 EPC are also not found persuasive by the board in respect of the method defined in independent claim 7.

2.4 In addition, the board sees no other reason that would question sufficiency of disclosure of the claimed invention within the meaning of Article 83 EPC. The board concludes that the application documents of the main request disclose the claimed invention in a manner sufficiently clear and complete for it to be carried out by the person skilled in the art (Article 83 EPC).

3. *Further prosecution - Remittal*

Since the decision under appeal was only based on the issue of sufficiency of disclosure addressed in point 2 above and the board is not convinced by the reasons given by the examining division in support of the refusal of the application, the decision must be set aside.

In addition, the decision did not address the question of whether the claims of the present main request complied with the remaining requirements of the EPC, and in particular with the requirements of Article 84, and of Article 52(1), together with Articles 54(1) and 56 EPC. In these circumstances, not remitting the case to the examining division would require the board to perform an assessment of these issues in both first- and last-instance proceedings and to effectively replace the examining division rather than review the contested decision in a judicial manner (*cf*. Article 12(2) RPBA 2020).

In view of these circumstances, the board considers that the pending examination of the remaining requirements of the EPC constitutes a special reason within the meaning of Article 11 RPBA 2020 justifying the remittal of the case to the examining division for further prosecution (Article 111(1) EPC) as requested by the appellant. Upon remittal, the examining division will proceed with the further examination of the remaining requirements of the EPC not dealt with in the appealed decision, and in particular of the requirements of Article 84, and of Article 52(1), together with Articles 54(1) and 56 EPC.

Order

For these reasons it is decided that:

1. The decision under appeal is set aside.

2. The case is remitted to the examining division for further prosecution.

The Registrar: The Chairman:

H. Jenney R. Bekkering

Decision electronically authenticated